Association between the Echinoid *Evechinus chloroticus* (Val.) and the Clingfish *Dellichthys morelandi* Briggs

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ABSTRACT: The echinoid *Evechinus chloroticus* (Val.) provides shelter and food for the clingfish *Dellichthys morelandi* Briggs. The latter appears to be attracted to the echinoid by visual recognition.

MANY ORGANISMS, including fishes, have been found living in external association with echinoids (Hyman, 1955; Pfaff, 1942). Pfaff described a clingfish, *Diademichthys deversor,* found among spines of the echinoid *Diadema.* He noted that one specimen had tube feet in the gut, and he summarized the literature on echinoid-clingfish relationships and pointed out that the precise nature of these relationships was not clear. The present paper suggests that the common New Zealand echinoid *Evechinus chloroticus* provides shelter and food for the clingfish *Dellichthys morelandi* and that the latter recognizes the echinoid visually.

While diving for echinoid samples at Kaikoura (South Island, New Zealand), the author noticed that adult and juvenile clingfish were very commonly found among the oral surface spines and attached to the substrate beneath the echinoid. Further, when an urchin was lifted off the substratum, any clingfish thus exposed darted rapidly under nearby, undisturbed urchins. It was then found that the clingfish were readily captured by removing *Evechinus* from rocks while holding a net containing several urchins nearby, and that when an urchin was added to a laboratory tank containing clingfish they darted rapidly underneath it. These observations suggested that the association between *Dellichthys* and *Evechinus* might be close and that the former might recognize the urchin visually. Accordingly, brief studies were begun to investigate the nature of the association: the nature of the responses of *Dellichthys* to certain stimuli were investigated experimentally, and gut contents of the clingfish were examined.

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METHODS

Clingfish were collected and kept with several *Evechinus* in running sea water laboratory tanks until the beginning of experiments.

To investigate the possible role of visual stimuli in attracting *Dellichthys* to *Evechinus,* an oblong clear perspex tray divided into three equal parts was used (Fig. 1). The stimulus (an urchin) was placed in one end section and five clingfish were introduced simultaneously into the center of the central section. Positions of the clingfish were then noted and scored, as shown in Figure 1, at 15-second intervals for 2 minutes; scores were positive (maximum of 10) if the fish moved toward the stimulus, negative if away from it. Each run was repeated with the stimulus at the oposite end of the tray to minimize possible bias. Each double run was repeated five times using different clingfish, and a mean score at each time-interval was calculated for the ten runs. One set of runs was performed with an intact *Evechinus* as stimulus, two with similar sized *Evechinus* tests denuded of spines, and one with an intact *Evechinus* in one end compartment and a denuded test in the other. In the last set scores were positive toward the intact urchin and negative towards the test.

To determine whether *Dellichthys* was chemically attracted to *Evechinus,* a Y-maze perspex olfactometer was used through which unfiltered sea water flowed continuously from a constant head at about 400 cc per minute (Fig. 2). Possible visual stimulation was eliminated by separating the *Evechinus* compartments from the maze and by shielding them from the fish; inlets and outlets in these compartments were arranged so that water flowed over the urchin before entering the maze. Five *Dellichthys* were placed at the tail of the maze and their positions

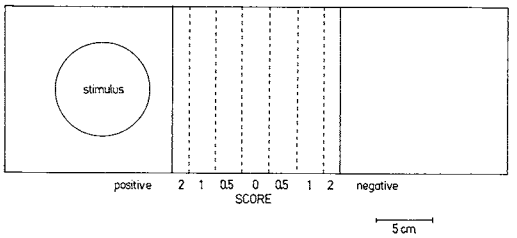

FIG. 1. Plan of apparatus used to test visual response of *Dellichthys morelandi* to *Evechinus chloroticus*. Positions of the fish in relation to stimulus scored as shown.

were noted at 5-minute intervals for 30 minutes and again at 60 minutes. Positions were scored positive if the fish moved into the arm of the maze through which "*Evechinus* water" flowed, negative if into the other. At the end of each run the apparatus was thoroughly washed in fresh water, and for the next run the urchin was placed in the opposite compartment to minimize bias. New fish were used in each run.

Gut contents of two samples of ten freshly collected *Dellichthys* were examined under dissecting and compound microscopes; one sample was taken in May 1968 and the other in July 1968.

RESULTS

Visual Stimuli

Mean scores for clingfish in the visual chamber are shown in Figure 3. Although an overall attraction (positive score) is shown to a denuded test (curves C) as well as to an intact *Evechinus* (curve A), the intensity of attraction toward the latter is greater; some fish responded negatively toward the intact urchin but more did so toward the test. Further, the behavior of the fish toward the two stimuli differed; fish which moved away from the test tended to remain immobile while those that initially responded negatively toward the intact urchin did not settle down and tended later to move toward the ur-

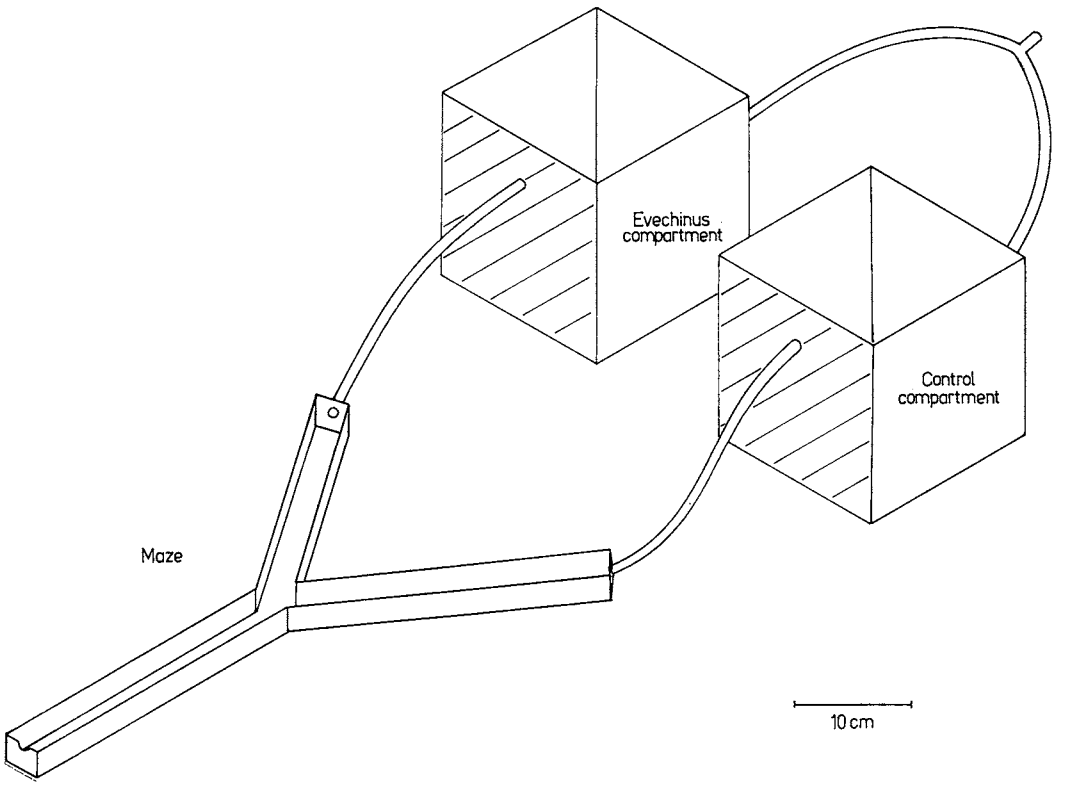

FIG. 2. Apparatus used to test olfactory response of *Dellichthys morelandi* to *Evechinus chloroticus*.

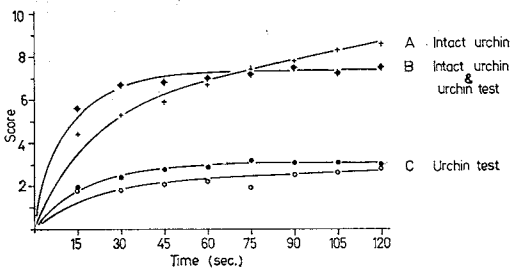

FIG. 3. Visual responses of *Dellichthys morelandi* to *Evechinus chloroticus* in apparatus of Figure 1. For explanation see text.

chin (in Figure 3, curve A does not reach an asymptote, but curves C do).

That the clingfish are able to distinguish an intact urchin from a denuded test is indicated by curve B which shows that attraction toward the intact animal overrules that toward the test. A few of the fish that moved toward the test end of the chamber tended to remain there producing the asymptote in curve B.

Olfactory Stimuli

Results of the choice-chamber experiments are given in Table 1 where numbers and percentages responding (i.e., moving into the arms of the maze), type of response, ratio of positive to negative responses, and significance of the difference of the ratio from 1 are shown for each observation.

At the first observation (after 5 minutes), significantly greater numbers of fish responded positively than negatively, although only 36.7 percent had responded by this time; more fish had responded positively than negatively at all observations up to 30 minutes, but they tended to become evenly distributed in the maze (equal numbers in each of the arms and in the tail) at later observations.

Gut Contents

Gut content analyses of 20 *Dellichthys* are shown in Table 2. All fish had material containing a purple pigment, apparently from the tube feet and/or pedicellariae in their hind gut, and all except one had at least a part of a tube foot or pedicellaria in the gut. No food other than parts of *Evechinus* was found.

DISCUSSION

The observations indicate a close association between *Dellichthys* and *Evechinus*. Independently, Moreland (personal communication), when collecting *Dellichthys*, "always found them associated with *Evechinus*."

The stimuli from *Evechinus* to which the clingfish respond appear to be chiefly visual and, although more experiments would be necessary for complete definition, the ability of the clingfish to distinguish an intact urchin from a denuded test suggests that the spines of *Evechinus* act as a sign stimulus. Color vision might also be involved since the denuded tests used in the experiments were a lighter color than the intact animal. It is possible that the two fish, *Aeoliscus strigatus* and *Diademichthys deversor*, which live among the spines of the long spined urchin, *Diadema*, also respond to visual stimuli from the urchin (Davenport, 1966:148; Marshall, 1965:214).

TABLE 1

RESPONSES IN CHOICE CHAMBER FROM 30 RUNS WITH FIVE *Dellichthys morelandi* PER RUN*

TIME (min)	RESPONSES					SIGNIFICANCE	
	Number	%	+ve	−ve	+ve/−ve	χ^2	P
5	55	36.7	37	18	2.1	6.56	$\simeq 0.01$
10	76	50.7	44	32	1.4	1.89	$0.25 > P > 0.10$
15	87	58.0	52	35	1.5	3.32	$0.10 > P > 0.05$
20	93	62.0	54	39	1.4	2.42	$0.25 > P > 0.10$
25	98	65.3	55	43	1.3	1.47	$0.25 > P > 0.10$
30	102	68.0	56	46	1.2	0.98	$0.50 > P > 0.25$
60	105	70.0	49	56	0.9	0.47	$0.50 > P > 0.25$

* For full explanation see text.

TABLE 2

GUT CONTENT ANALYSES OF 20 *Dellichthys morelandi* FROM KAIKOURA, NEW ZEALAND

SPECIMEN	LENGTH (mm)	GUT CONTENTS				
		Tube feet	Xtalline plates[a]	Pedicellaria	C.S.R. pedicel.[b]	Pigmented material[c]
1	24	10	–	–	–	++
2	22	8	2	–	–	++
3	21	7	–	–	1	++
4	20	3	4	–	–	++
5	17	2	–	–	–	+
6	20	6	–	–	–	+
7	17	–	–	1	2	+
8	17	1	–	–	–	+
9	15	–	–	1	1	+
10	14	–	1	1	–	+
11	29	–	–	1	–	++
12	26	–	3	–	–	+
13	25	1	–	6	1	++
14	25	–	1	–	–	+
15	23	1	–	–	–	+
16	22	1	–	–	–	+
17	22	–	–	2	–	+
18	20	3	–	–	–	++
19	19	–	–	–	–	+
20	18	–	–	1	–	+

[a] Xtalline plates are from tube feet (one per foot).
[b] C.S.R. pedicel. = calcareous supporting rod of pedicellaria.
[c] Relative amount of pigment indicated by + or ++.

The choice chamber experiments indicate that *Dellichthys* might also be chemically attracted to *Evechinus,* but in the apparatus used the intensity of this response was not strong. It is possible that a process of habituation—"the . . . waning of a response as a result of repeated stimulation in the absence of reinforcement" (Thorpe, 1956; see also Clark, 1960)—explains the fall in the ratio of positive to negative responses since fish could not encounter an urchin in the maze.

Evechinus populations at Kaikoura are markedly clumped (Dix, 1969), and visual attraction could be important in maintaining the urchin-clingfish association, particularly if the clingfish move from urchin to urchin. Rapid and visually directed movement could ensure a minimum risk of predation while in the open. Laboratory observations have indicated that blennies (species not known) attack exposed *Dellichthys,* but although these blennies have been observed in urchin populations, natural predation has not yet been observed. Visual attraction is also likely to be specific, ensuring that the clingfish reaches its source of food and shelter.

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